Claims

We claim:

1. A method of forming a heat exchanger, comprising:
   a. forming a manifold layer defining a plurality of apertures; and
   b. forming an interface layer comprising one or more narrowing trenches, each aperture positioned on one side of a narrowing trench, whereby a path is defined from a first aperture, through a narrowing trench, and to a second aperture.

2. The method of claim 1, wherein the interface layer comprises a material exhibiting anisotropic etching.

3. The method of claim 2, wherein the material comprises a <110> oriented silicon substrate.

4. The method of claim 3, wherein forming an interface layer comprises etching the <110> oriented silicon substrate in an etchant to produce a <111> oriented surface defining a sloping wall of a narrowing trench.

5. The method of claim 4, wherein the etchant comprises potassium hydroxide (KOH).

6. The method of claim 4, wherein the etchant comprises tetramethyl ammonium hydroxide (TMAH).

7. The method of claim 1, wherein the one or more narrowing trenches are formed by a machining process selected from the group consisting of milling, sawing, drilling, stamping, EDM, wire EDM, coining, die casting, and investment casting.

8. The method of claim 1, wherein the one or more narrowing trenches are formed by a process selected from the group consisting of electroplating, metal injection molding, LIGA processes, and casting.

9. The method of claim 1, wherein the manifold layer and the interface layer are formed of a monolithic device.

10. The method of claim 1, further comprising coupling the manifold layer to the interface layer.

11. The method of claim 10, wherein coupling the manifold layer to the interface layer comprises adhesively bonding the manifold layer to the interface layer.

12. The method of claim 10, wherein coupling the manifold layer to the interface layer comprises thermally fusing the manifold layer to the interface layer.

13. The method of claim 10, wherein coupling the manifold layer to the interface layer comprises anodically bonding the manifold layer to the interface layer.

14. The method of claim 10, wherein coupling the manifold layer to the interface layer comprises eutectically bonding the manifold layer to the interface layer.

15. The method of claim 1, wherein the manifold layer comprises a material selected from the group consisting essentially of a plastic, a glass, a metal, and a semiconductor.

16. The method of claim 1, wherein forming the manifold layer comprises forming a first plurality of interconnected hollow fingers and a second plurality of interconnected hollow fingers, the first plurality of interconnected hollow fingers providing flow paths to the one or more first apertures and the second plurality of interconnected hollow fingers providing flow paths from the one or more second apertures.

17. The method of claim 16, wherein the first plurality of interconnected hollow fingers and the second plurality of interconnected hollow fingers lie substantially in a single plane.

18. The method of claim 16, further comprising coupling a pump to the first plurality of interconnected hollow fingers.

19. The method of claim 1, further comprising coupling a heat-generating source to the interface layer.

20. The method of claim 19, wherein a bottom surface of the interface layer is integrally formed with the heat-generating source.

21. The method of claim 19, wherein the heat-generating source comprises a semiconductor microprocessor.

22. The method of claim 18, further comprising introducing a cooling material to the pump, so that the pump circulates the cooling material along the first plurality of interconnected hollow fingers, to the one or more first apertures, along a plurality of narrowing trenches, to the one or more second apertures, and to the second plurality of interconnected hollow fingers, thereby cooling the heat-generating source.

23. The method of claim 22, wherein the cooling material comprises a liquid.

24. The method of claim 23, wherein the liquid comprises water.

25. The method of claim 22, wherein the cooling material comprises a liquid/vapor mixture.

26. The method of claim 1, wherein each aperture lies substantially in a single plane, parallel to a lower surface of the interface layer.

27. The method of claim 1, wherein the manifold layer comprises a surface that extends into each narrowing trench and substantially conforms to a contour of each narrowing trench.

28. The method of claim 1, wherein a narrowing trench has a depth:width aspect ratio of at least approximately 10:1.

29. The method of claim 1, further comprising coupling an intermediate layer between the manifold layer and the interface layer, the intermediate layer comprising a plurality of openings positioned over the plurality of apertures, thereby controlling the flow of a cooling material to the paths.

30. A heat exchanger comprising:

a. a manifold layer defining a plurality of apertures; and

b. an interface layer comprising a plurality of narrowing trenches, each aperture positioned on one side of a narrowing trench, whereby a path is defined from a first aperture, through a narrowing trench, and to a second aperture.

31. The heat exchanger of claim 30, wherein the interface layer comprises a material exhibiting anisotropic etching.

32. The heat exchanger of claim 31, wherein the material exhibiting anisotropic etching comprises a <110> oriented silicon substrate.

33. The heat exchanger of claim 32, wherein the interface layer is formed by etching the <110> oriented silicon substrate in an etchant to produce a <111> oriented surface defining a sloping wall of a narrowing trench.

34. The heat exchanger of claim 33, wherein the etchant comprises potassium hydroxide (KOH).

35. The heat exchanger of claim 33, wherein the etchant comprises tetramethyl ammonium hydroxide (TMAH).

36. The heat exchanger of claim 30, wherein the narrowing trenches are formed by a machining process selected from the group consisting of milling, sawing, drilling, stamping, EDM, wire EDM, coining, die casting, and investment casting.

37. The heat exchanger of claim 30, wherein the narrowing trenches are formed by a process selected from the group consisting of electroplating, metal injection molding, LIGA processes, and casting.

38. The heat exchanger of claim 30, wherein the manifold layer and the interface layer are formed of a monolithic device.

39. The heat exchanger of claim 30, wherein the manifold layer is coupled to the interface layer.

40. The heat exchanger of claim 39, wherein the manifold layer is coupled to the interface layer by adhesive bonding.

41. The heat exchanger of claim 39, wherein the manifold layer is coupled to the interface layer by thermal fusing.

42. The heat exchanger of claim 39, wherein the manifold layer is coupled to the interface layer by anodic bonding.

43. The heat exchanger of claim 39, wherein the manifold later is coupled to the interface layer by eutectic bonding.

44. The heat exchanger of claim 30, wherein the manifold layer comprises a material selected from the group consisting essentially of a plastic, a glass, a metal, and a semiconductor.

45. The heat exchanger of claim 30, wherein the manifold layer comprises a first plurality of interconnected hollow fingers and a second plurality of interconnected hollow fingers, the first plurality of interconnected hollow fingers providing flow paths to the one or more first apertures and the second plurality of interconnected hollow fingers providing flow paths from the one or more second apertures.

46. The heat exchanger of claim 45, wherein the first plurality of interconnected hollow fingers and the second plurality of interconnected hollow fingers lie substantially in a single plane.

47. The heat exchanger of claim 45, further comprising a pump coupled to the first plurality of interconnected hollow fingers.

48. The heat exchanger of claim 30, further comprising a heat-generating source coupled to the interface layer.

49. The heat exchanger of claim 48, wherein the heat-generating source comprises a semiconductor microprocessor.

50. The heat exchanger of claim 48, wherein the heat-generating source is integrally formed to a bottom surface of the interface layer.

51. The heat exchanger of claim 30, wherein each aperture lies substantially in a single plane, parallel to a lower surface of the interface layer.

52. The heat exchanger of claim 30, wherein the manifold layer comprises a surface that extends into each trench and substantially conforms to a contour of each narrowing trench.

53. The heat exchanger of claim 30, wherein a depth:width aspect ratio for at least one of the plurality of narrowing trenches is at least 10:1.

54. The heat exchanger of claim 30, further comprising an intermediate layer positioned between the manifold layer and the interface layer, the intermediate layer comprising a plurality of openings positioned over the plurality of apertures, thereby controlling the flow of a cooling material to the paths.